Sustainable Energy in Military Base Design & Layout

A Thesis
Presented to
The Academic Faculty

by

Ira L. Campbell Sr

In Partial Fulfillment
of the Requirements for the Degree
Master of Architecture in the
School of Architecture

Georgia Institute of Technology
May 2016

Sustainable Energy in Military Base Design & Layout

Approved by:

Godfried Augenbroe, Advisor
School of Architecture
Georgia Institute of Technology

Dr. Jason Brown
School of Architecture
Georgia Institute of Technology

Merrill Elam
School of Architecture
Georgia Institute of Technology

Date Approved: May 4, 2016

This Thesis is dedicated to all those who have helped me on this journey.

ACKNOWLEDGEMENTS

I wish to thank Professor Godfried Augenbroe & Dr Jason Brown for all your guidance and direction.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

eMAT	Energy Mat
EPU	Energy Processing Unit
pGEN	Power Generation
pGenFamily or pGen Portfolio	Power Generation Family
eTIRE	Energy Tire
EPC	Energy Processing Center

SUMMARY

Where Does this Leave Us?

The ability for a military installation to become a net zero energy installation will depend on many factors, and may not be practically achievable. The overall energy needs of the system are supplied by a smart microgrid that includes battery storage. It is capable of seamlessly integrating energy from a variety of sources including renewables.

1. Reducing Energy Demand by Engaging People

Another intent of this paper is to be a resource for military base designers, and those who provide energy to those bases. Improving the energy efficiency for military installations is not an easy or a quick fix. It will take time in order to reach goals of reduced the military's dependency on fossil fuels and improve our energy security. These suggestions are intended to perhaps challenge the current status quo to push the level of commitment in order to achieve net zero dependency.

The overall goal of a net zero energy assessment is to recommend an optimal energy strategy that will support the installation’s energy goals. In determining this strategy, consideration must be given not only to the net zero energy goal but also to factors including mission compatibility, energy security, project economics, military agency goals, federal mandates, site resources, funding, and staff availability. This last step of project assessment prior to implementation action should address project selection, the implementation approach, and a basic financial analysis at a sufficient level of detail to enable decision makers to proceed with project implementation.

2. Installation Energy Efficiency

Providing secure, stable, and dependable energy for military installations requires taking a drastic measures; starting with drafting congressional laws that promote more energy sustainability and less energy reduction. The Department of Defense(DoD) in turn, should mandate all military installations to design and layout bases to strict sustainable energy standards and not to energy efficient standards . These standards, by all accounts, has not reduced our dependency on fossil fuels. And although there is probability no one realistic method to attaining net zero energy, there are a few ways in which we can start moving towards that goal. Here are a few of them:

3. Integrated Technologies

Because military installations exists "in every clime and place", we should look to utilize the indigenous energy sources of the area surrounding the bases. Where in some hostile cases that may not be possible, but where it is possible, integrating all low cost, high energy yield technology can drastically reduced our dependency on fossil fuels. This new approach to sustainability should be a formula that takes into consideration all the available energy resources, be it manmade or natural, to provide the necessary power requirements for bases, buildings and structures. This formula should be calculated in the pre-design phase, and not after the fact. For example, in climates with temperatures consistently over 80 degrees for over 8 months of the year, every roof top should be covered with some type of photovoltaic device; not just having a field of solar panels. And if all the buildings and structures in a desert climate must have solar panels in order to satisfy the energy requirements for the base, then this should be integrated during the pre-design phase. By incorporating sustainability from the onset alone would probably provide at least 50% of the power requirements for US military bases. Every aspect of a base must be involved. Every single inch of the base must be assessed as a potential energy generator. By looking at everything as a energy generator, we can perhaps, match them with emerging technologies that best fits the area, building, structure, body of water, etc. Most of the large bases have their own gyms, schools, and athletic fields. Perhaps these areas become major sources of energy. Gathering places or frequently utilized places can potentially be the

4. Build Sustainable Structures

Today we build structures that conserve energy or reduce energy consumption. Going forward, as the need for more energy grows, the need for buildings and structures to not just conserve energy, but to generate energy grows exponentially. Just as we demand our structures to heat, cool, and protect us from the elements, we have to place those very same demands on our structures to generate dependable energy. A truly sustainable building. To achieve this very aggressive goal, we must change the way we design, build, and power buildings. A building, or any structure, should have the capability to generate its own power. This should be the new standard. Instead of awarding a structure a certification for energy reduction or saving, buildings should be awarded to generate energy.

5. Affordable Sustainability: Supply & Demand

One of the major steps to achieving the net zero goal is driven by economics. The more people involved in the sustainability push, the more affordable energy becomes. More specifically, manufacturers that produce energy products and equipment will drive the cost down of the current technology. As the cost goes down, more and more architects & designers will integrate sustainability in their design process. As more sustainability considerations are integrated in the design process, military bases will have structures that sustains themselves.

6. Personal Responsibility for Personal Power

Military service members use all the smart devices that the civilian population uses. And in some case, even more. After spending 21 years in the Marine Corps, I can tell you for a fact that marines will keep their personal devices charging continuously. Power for military members is free. They can plug their devices in anywhere anytime. What would the impact on the overall power requirements for a building or barracks be if individuals were responsible for generating their own power? This is not a suggestion that service member should pay for the power used, but that they should generate their own energy to power their personal devices.

7. Micro-grids: "In House Power"

With the exception of services that civilians provide, most bases are almost self sufficient. Except when it comes to energy. Just as the civilian community is dependent on power companies to provide power, military bases are no different for the most part.

And if that base is located on foreign soil, then providing power really becomes problematic. Small, scalable micro-grids could be one of the possible solution to this problem. By installing these grids with smart technology that power various structures and equipment, any base can gain energy independent. Power generators located throughout the base can supply these grids with "on demand" power. Collecting data on building usage can help clarify how and where we can use energy smarter.

Reports from the U.S. Energy Information Administration show nearly 70% of America's electricity is generated by natural gas and coal. The environmental impact of greenhouse gas emissions and the rising cost of those non-renewable fuels, along with the potential doubling of global electricity consumption in the coming years, requires the urgent need for creative, sustainable methods of generating electricity. The prospect of sustainably converting vehicle motion and deceleration (vehicle energy) into electricity represents significant positive environmental impact and alternative energy opportunities. I have over 80 patents to be filed, with at least another 70 potential patents in a closely related field. Here are some facts to consider:

The United States has the world's largest transportation system. In 2006, Americans traveled 5.2 trillion person-miles in vehicles and moved 4.6 trillion ton-miles of freight. This travel consumed 28.6 quads of energy, all but about 4% in the form of petroleum.

8. Smart Micro-grids and Energy Storage

The current state-of-the-art power grid includes minimal renewable energy, no intelligent distribution, minimal or no energy storage, ad hoc dispatch, uncontrolled load demands, and excessive distribution losses. Micro-grids are envisioned as local power networks that utilize distributed energy resources and manage local energy supply and demand. Micro-grids can improve operating efficiency, enhance the use of renewables, and increase the reliability of electric power delivery systems. Energy technology demonstrations are enabling DoD to better plan, analyze, and evaluate the operational benefits and risks of deploying micro-grids. The introduction of dynamically stable, modular, and cost-effective energy micro-grids that can seamlessly operate in grid-parallel and off-grid modes will reduce DoD energy costs and carbon emissions and make mission-critical loads more resilient and secure.

9. Renewable Energy Generation

To meet its goals on environmental, energy, and economic performance, DoD requires rapid and effective deployment of new clean, secure, low-carbon energy technologies for its installations. Increasing the use of renewable energy sources and achieving efficiency improvements in other non-centralized energy generation alternatives are essential to reduce installations' energy consumption and carbon footprint and improve energy security. Demonstrations are focused on renewable energy sources that are mission compatible and at the appropriate scale for military installations. Cost, performance, and reliability data gathered from operational deployment of innovative renewable energy sources on DoD installations will inform decisions on their widespread applicability across DoD. Demonstrations involve advanced solar, geothermal, and waste-to energy technologies.

10. Advanced Component Technologies to Improve Building Efficiency

Innovative technologies in energy efficient lighting, heating, and air conditioning can reduce energy demand for all types of DoD buildings. Advanced lighting control technologies integrate scheduling, personalized dimming, daylight harvesting, and occupancy sensing to reduce the energy consumed for building lighting needs. Effective use of waste heat and high-performance cooling technology can enhance energy efficiency and comfort while leading to substantial reductions in peak demand on the power grid. Other technology demonstrations focus on advanced controls for increasing boiler efficiency, roof systems, building envelopes, and waste heat recovery.

11. Advanced Building Energy Management and Control Technologies

Building energy systems often consume much more energy than is necessary due to system deviation from the design intent and energy managers' lack of visibility of system performance. Demonstrations of emerging capabilities in building energy management systems, performance monitoring, and diagnostics can enable DoD energy managers to increase building efficiency and reduce utility costs. Retrofitting existing building stocks represents the largest and fastest way to reduce DoD’s energy consumption. Existing modeling and simulation tools, however, cannot accurately capture the dynamic coupling among building subsystems. Demonstration projects also focus on developing the methodology and the physics- and dynamics-based analysis tool set necessary to deliver higher energy performance for building retrofits.

12. Tools and Processes for Design Assessment and Decision Making

Building managers, facility managers, regional managers, and DoD portfolio managers require tools and methods to improve their decision making related to energy usage and investments. Demonstration projects are focused on advances both in the design of new buildings and in the identification and design of major retrofits. Energy savings can occur through improved understanding of energy usage, energy needs, and opportunities, but managers often lack adequate information and analytic tools to make optimal decisions. Demonstrations will gather the data needed for DoD to deploy cost-effective, innovative methods to meet energy goals by increasing the performance of decision makers at all levels of the energy usage and management system.

And the deployment of a micro-grid is expected to increase system robustness, resilience and security, deliver higher power security to critical loads, allow renewable integration and enable inclusion of emerging technologies.

CHAPTER 1

PURPOSE OF STUDY

The purpose of this study is to exlpore the possibilities of power generation using human and mechanical means. This paper will introduce alternative means, methods, and procedures for the implementation of cutting edge technologies to address the energy needs for today and the future. Further, this project will serve as an aid in the development of a base camp facility layout optimization system by understanding the proximity relationships between base camp components, developing a facility layout domain, and comparing generated layouts to existing models and camps. The first phase involved collecting input from a variety of sources to gain an understanding of the proximity relationships between fifteen common base camp facilities.

CHAPTER 2

A BACKWARD GLANCE

Military installations have been in the US military's repertoire since its formation. An installation is an evolving military facility that supports the military operations of a deployed unit and provides necessary support and services for sustained operations. Because of the recent proliferation of deployments, the military now uses smaller installations called base camps. These small, somewhat mobile installations are being used from Okinawa to Iraq to Kosovo. Base camps usually begin as tactical assembly areas and become defacto base camps over time. This process calls upon the military engineers to develop and construct camp layouts that are tactically sound and help the warfighters to complete their missions in less than ideal situations.

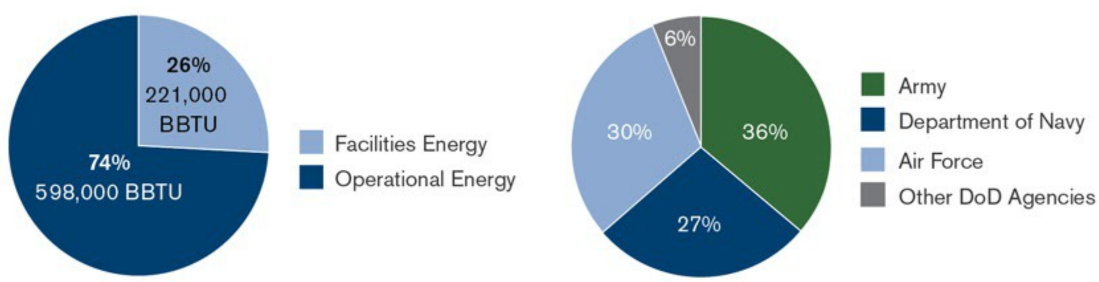


Figure 1. DoD Energy Pie Chart

DoD has decided to focus on developing renewable energy on its own installations in lieu of the common past practice of purchasing renewable energy credits. Each of the Military Departments has set a target to develop one gigawatt of renewable energy by FY 2025. At the heart of the Department's vision for greatly expanding its renewable energy capacity—especially on military installations with their thousands of acres of land compatible with large scale renewable energy development—is a reliance on alternative financing. Another central theme of the Department's vision for facility energy is advanced microgrid technology. Advanced microgrids are a "triple play" for DoD's installations: they will reduce installation energy consumption and costs, facilitate the incorporation of renewable and other on-site energy generation, and—combined with energy storage—allow an installation to shed non-essential loads and maintain mission-critical loads if the grid goes down. Finally, the DoD budget in FY 2013 for the Installation Energy Test Bed is $32 million. The program helps firms overcome the barriers that inhibit innovative technologies from being commercialized and/or deployed on military installations by using installations as a distributed test bed to demonstrate and validate the technologies in a real-world environment. In 2008, DoD and DOE defined a joint initiative to address military energy use by identifying specific actions to reduce energy demand and increase use of renewable energy on DoD installations. A task force comprised of representatives from the Office of the Secretary of Defense (OSD), the four military services, DOE's Federal Energy Management Program (FEMP), and the National Renewable Energy Laboratory (NREL) was established. In light of DoD priorities, early attention was given to the possibility of net zero energy military installations; that is, installations that would meet their energy needs with local renewable resources. Marine Corps Air Station (MCAS) Miramar was selected by the task force to be the prototype installation for net zero energy assessment and planning, on the basis of Miramar's strong history of energy advocacy and extensive track record of successful energy projects.

In 2010, U.S. armed forces consumed more than five billion gallons of fuel in military operations. The number one factor driving that fuel consumption is the nature of today's defense mission. 21st century challenges to U.S. national security are increasingly global and complex, requiring a broad range of military operations and capabilities – and a large and steady supply of energy. At the same time that military demand for energy is growing, global and battlefield energy supplies are under pressure. At the operational and tactical level, fuel logistics have proven vulnerable to attack in recent conflicts.

The DoD is working to reduce its demand for oil. Starting with Executive Order 13514 in 2009, all federal agencies get annual scorecards that track opportunities and set goals for reductions of pollution, improvements in efficiencies and cost savings. This "what gets measured gets managed" approach helped lead to an 11.8 percent reduction in oil consumption by the DoD in 2011 from its 2005 benchmark year.

CHAPTER 3

CURRENT MILITARY STRATEGIES

Current operations entail more fuel, risks, and costs than are necessary, with tactical, operational, and strategic consequences. Yet the Department's institutions and processes for building future military forces and missions do not systematically consider such risks and costs. The Department needs to integrate operational energy considerations into the full range of planning and force development activities. Energy will be, in itself, an important capability for meeting the missions envisioned in the QDR and the National Military Strategy.

Reducing demand, expanding supply, and building an energy-secure force will mean a The positive outcomes for the Department include:

- *Saving lives now lost moving and protecting fuel on the battlefield;*

- *Improving the range, endurance, and reliability of ground, air, and naval forces and information assets;*

- *Lightening the logistics load and reducing the vulnerability of fuel supply lines;*

Refocusing some combat forces and capabilities from supply lines and fuel logistics to operational missions;

●Strengthening the Department's resilience to energy price and supply volatility and disruption;

●Posturing the future force for success in meeting 21st century challenges by better aligning resources to tactical, operational, and strategic goals;

Building capacity and stability in and good relations with partner nations by sharing improved operational energy capabilities, including in civilian applications; and contributing to national goals, such as reducing reliance on fossil fuels, cutting greenhouse gas emissions, and stimulating innovation in the civilian sector.

There are not many large scale military installations that are in the planning stages currently. Most bases that are being built are small outposts that eventually morps into installations. When it comes to small combat outposts, moving the fuel to that last tactical mile is the most dangerous, the most difficult, and sometimes, the most tactically operationally significant. Finding ways to make those outposts less dependent on the supply line, while ensuring forward-deployed personnel still have the energy they need to operate, is a very worthy effort. Solar power is one method being tested to give troops a way to operate without the burden of being tied to a logistical system. Efficiency and supply line concerns are important but building capability into the future force is essential.

Once we field a force, our ability to improve it, to make it fundamentally better is limited. DOD can do some very important things, like rapid fielding of new equipment and refurbishing older equipment, but that isn't the most efficient means of solving problems.

"We have to get into how we actually plan, require and acquire," Sharon Burke, a former Department of Defense official said. "We have to get to a point where we're not making convenient assumptions that we'll have perfect access and perfect allies and perfect supplies and everything will arrive where we need it, when we need it … because that's not the world that we live in now, and it's not the world that we're going to be living in for the long view.

"I think we need to be challenging ourselves more," she added. "We need to see energy as the enabler that it is -- as a critical enabler that you can't take for granted."

General Martin E. Dempsey, the former Joint Chiefs of Staff noted that within the Department of Defense, the "energy culture" has dramatically changed and improved since the days he was a young Army armor officer.

But, he noted, "*Today's war fighters require more energy than at any time in the past and that requirement is not likely to decline," he explained. "During World War II, supporting one Soldier on the battlefield took one gallon of fuel per day. Today, we use over 22 gallons per day, per Soldier."*

Dempsey recognized efforts in designing more fuel efficient Ground Combat Vehicles, utilization of hybrid technologies, investments in backup fuel cells for military installations, and the Army's Net Zero pilot programs.

B*ecause of the increase in the number of Operations Other Than War (OOTW) deployments and the ever- increasing complexity of base camps, as well as large base installations, some type of layout optimization tool would be useful in planning and constructing bases.*

Military planners would also benefit from a decision support tool that optimizes the facility layout for a base camp location while providing flexibility for modification and expansion. This executive summary presents our progress in determining base camp functions and the very specific knowledge requirements for base camp site-selection and facility layout. It concludes with a discussion about the future research, highlighting the system requirements for the decision support system. A first step in addressing this problem is to clearly define a base camp and identify its primary functions. To this end, we define a base camp as an evolving military facility that supports the military operations of a deployed unit and provides the necessary support and services for sustained operations. Using this definition, a base camp's primary function is mission support. To accomplish this support, it must provide four key services: force protection, critical infrastructure, training support, and maintenance support. A functional decomposition of these services provides insight for base camp location and facility layout decisions. Force protection programs must safeguard and secure people, facilities, equipment, supplies, transportation networks, and information. These programs must adapt to the threat, mission, and environment.

Classifying the critical infrastructure will help managing the base camp real estate by creating zones similar to those used by city master planners. Typical base camp infrastructure can be classified as housing, soldier support, unit support, and morale-welfare-recreation. Housing is further defined by type such as tent or sea hut. Unit support is decomposed into elements that include motor pools, unit headquarters, electric power, water (potable and treatment), road networks, fuel storage, and ammo holding areas. The soldier support component is representative of areas in the base camp dedicated to dining facilities, aid stations, chapels, education center, postal service center, mail rooms, finance support, barber, post exchange, food concession and fire protection. The morale-welfare-recreation component is comprised of fitness centers, theater center, common areas, library, TV rooms, athletic fields, and running trails. OOTW missions make individual and collective training support critical. Units need areas to train on tasks they may not normally perform. They also require training resources to maintain proficiency on essential tasks that they probably will not perform in theater. Equally important is providing maintenance areas and facilities to support equipment and facility. These component lists for the four critical services are not exhaustive and are a function of resources, politics and time. In general, the larger the facility and length of deployment will impact on the number and types of facilities. The important point is that stakeholders desire quality of life for deployed soldiers and theater commanders establish the guidelines on facilities. A few more components of the definition need emphasis. A base camp supports a deployed unit. Although the camp may have permanently assigned personnel, the units will rotate through the facility.The next point is that the base camp provides for sustained operations. This implies a requirement for continuous re-supply and the establishment of a logistical support structure.

Within the realm of sustainability, the Department of Defense's near-term focus is on facility energy. DoD is pursuing an ambitious facility energy strategy to reduce its $4 billion annual facility energy bill and improve the energy security of its installations. The Department's facility energy strategy, designed to reduce energy costs and improve the energy security of our fixed installations, has four inter-related elements:

1. Reduce the demand for fossil fuels through conservation and improved energy efficiency;
2. Expand the supply of renewable energy and other forms of distributed (on-site) energy;
3. Enhance the energy security of our installations directly (as well as indirectly, through the first two elements); and
4. Leverage advanced technology.

The Department budgeted more than $1.1 billion in FY 2013 for energy conservation and efficiency, almost all of which will be directed to retrofits on existing buildings, such as more energy efficient lighting, double-pane windows, energy management control systems, new roofs, and high-efficiency heating, ventilation and air-conditioning systems.

CHAPTER 4

WHY DO WE NEED ALTERNATIVE POWER SOURCES?

Strategically, energy is important for economic stability and growth, with nations around the world increasingly competing for the same energy resources. As long as U.S. forces rely on large volumes of energy, particularly petroleum-based fuels, the vulnerability and volatility of supplies will continue to raise risks and costs for the armed forces. Here are some of the main point of why we need alternative energy sources:

1. **They are sustainable.** From sun to wind to bioenergy, the U.S. renewable energy base is virtually intact. And because these alternative energy sources are naturally replenished day after day, they are a source of virtually endless energy.
2. **They are environmentally friendly.** We rely on the Earth to provide the air, water, and food we need for life. Using alternative energy reduces the amount of digging, drilling, and mining we do, thereby reducing stress on the planet.
3. **Their use provides a reduction in greenhouse gas emissions.** Traditional fossil-fuel based energy sources release carbon dioxide in the air, resulting in what's known as the greenhouse effect, which many believe is responsible for climate change. Since renewable energies don't result in CO2 emissions, they offer a viable solution to this problem.
4. **Their low degree of emission leads to cleaner air.** All of the chemical byproducts and substances that are released in the air by the processing and burning of fossil fuels ultimately affect the air we breathe. Renewable energy

provides an important step toward a less polluted planet.

5. **They increase our energy security.** The use of alternative energy sources renders us less reliant on the import of fossil fuels, which in turn makes us less vulnerable to the ups and down of the market and the influences of an ever-changing political landscape.

6. **They reduce the need for oil drilling.** New drilling prospects still exist, but many involve further despoiling of some of the natural wilderness areas we have left.

7. **They provide financial stability for the consumer.** A homeowner with an alternative energy system in place is no longer vulnerable to fluctuations in the gas and oil markets driven by the ever-changing dynamics of supply and demand.

8. **There are often subsidies available.** Increasingly, governments worldwide are putting into place significant financial incentives for individual homeowners switching to alternative energy systems. Often this can help offset the initial installation costs of an alternative system.

9. **They have the potential to turn into viable new industries.** Many of the companies responsible for the development of alternative energy sources are some of the more fore-thinking and cutting-edge organizations in the world. Plus, all the manufacturing, installation, retrofitting, and so on involved in the use of these systems carries the potential to create many new jobs.

10. **They can save you money.** In the end, using alternative energy sources can save you money. Although you typically have to make an initial investment, these types of systems usually pay for themselves over time, given that their primary

energy source (i.e. sun or wind) is essentially free.

CHAPTER 5

THE WAY AHEAD

DOD has outlined a number of strategic energy security objectives that are central to the defense of the nation. These objectives and some examples of how DOD is implementing the strategies include:

Reducing oil dependence

The DOD set a goal of reducing petroleum use by 20 percent by 2015. The Air Force plans to cost-competitively acquire 50 percent of its domestic aviation fuel by 2016 via an alternative fuel blend that is cleaner than conventional petroleum fuel. The Department of Navy has set aggressive goals to decrease fossil fuel use by all vessels by 50 percent by 2020, and reduce petroleum use in non-tactical vehicles by 50 percent by 2015.

CHAPTER 6

DESIGN APPROACH TO ENERGY HARVESTING

"To optimize a base camp, the facilities, or components, the physical infrastructure of a base camp must be arranged in the most efficient manner. Some common types of facilities include motorpools, chapels, and ammunition holding areas" General Jack Dempsey.

DoD is uniquely positioned to serve as a platform to develop and install new technologies. The Army, Navy, and Air Force are each implementing detailed plans to achieve ambitious renewable energy and energy efficiency targets at military installations. These plans include a one gigawatt (GW) per service target of renewable power capacity at military facilities, primarily via third- party financing.

The U.S. Department of Defense plans to open up 16 million acres of its land for renewable energy development, which it hopes will create a boom of solar, wind and geothermal projects and provide clean power to military bases. The vast majority of the military bases rely on power from nearby utilities, and they depend on backup generators during blackouts, said Dorothy Robyn, former Deputy Under Secretary of Defense for Installations and Environment. The military is keenly interested in creating "micro-grids" for its bases. A micro-grid is a mostly self-sufficient base of power generation and storage, which allows for banking the electricity (using batteries or other technologies) for later use. A micro-grid can still be connected to the regular electric grid, but it will take power from local utilities only when its own power plants aren't able to generate enough to meet the demand. Renewable energy will allow a military base to maintain critical operations for weeks or months if an electric power grid goes down.

Sustainable Buildings: The greatest challenge for DoD will be meeting the sustainable buildings goal. DoD currently has almost 52,000 buildings larger than 5,000 square feet, meaning that approximately 7,800 buildings should have been renovated by FY 2015—often extensively—in order to meet the Guiding Principles criteria. Aside from the sheer magnitude of the challenge, another issue is the Guiding Principles threshold. DoD has a rapidly increasing number of high performance, sustainable buildings that have LEED Silver certification or higher. However, these buildings often do not meet 100 percent of the criteria in the Guiding Principles, and therefore do not count toward the metric. The Department's facility investment strategy is focused on mission needs, not on upgrading buildings that already meet a mission need to meet the Guiding Principles. The Department is committed to ensuring our limited investments in new construction and major renovation are meeting the Guiding Principles and lowering life-cycle costs, although this is expected to yield only modest gains in the Guiding Principles metric.

Unfortunately, no known recent work in the field of base camp layout optimization has been completed. This was the main motivator in studying base camp facility design. The Construction Engineering Research Laboratory (CERL) is currently attempting to optimize base camp layouts given terrain limitations using GEOBEST, a U.S. Air Force site location planning tool, but has yet to obtain suitable results. Other *initiatives, such as the Contingency Facilities in Future Base Camps by the Office of the Chief of Engineers and capstone projects at the United States Military Academy, have an interest in finding an optimal base camp layout.*

But what if there were existing & emerging innovations that could generate enough clean energy to power an entire installation? Regardless of the size?

CHAPTER 7

GENERATION NEXT: THE POWER GENERATION FAMILY

(pGEN PORTFOLIO)

Here are some ideas that are improvements on existing technology that will provide a military installation with dependable constant power for generations to come. The pGEN Family technology can be integrated in the existing infrastructure with minimal downtime or incorporated in new construction. These inventions can transform a external energy dependent base in to a energy self sufficient base. And this can be accomplished by producing clean energy. Power sources will come from the least likely sources. Power companies will take on more of a regulatory/monitoring agency rather than a power supplier. With these inventions, other industries will flourish. Such as the electric vehicles; thereby reducing our dependency on fossil fuels. Manufacturing industries will experience a boom(again). If these ideas prove to be correct, there will be many more patents that will be filed in the energy field alone. As you know, a micro-grid is defined as an integrated energy system consisting of interconnected distributed generation (DG) sources, along with energy storage devices and controllable loads located at or near the end-use customers at the distribution level. This concept is not new, but it has be used in a novel way. Lets consider this, *where ever there is motion, there is potential for kinetic energy. Trucks, automobiles, trains, and even people all generate some level of kinetic energy. The heavier and more consistent the traffic, the greater the wasted energy and the greater the potential for kinetic energy. The pGEN Portfolio is pivitol in capturing* *and harvesting this energy in an efficient and economical way; and redistributing it in that exact same fashion.* You can't just create energy for no cost. However, you can produce it at a minimal cost. But if we were to multiply thousands of cars traveling over the eMAT, the energy created could potentially power the surrounding structures, roadways, parks and even schools. Let's take a look at Naval Air Station North Island in Coronado California.

Figure 2. Energy Consumers

1. Energy Consumers

The map above of North Air Station North Island in Coronado, California. It is a prototypical military base with air, ground and sea components. The highlighted areas are dense areas with high volumes of traffic. With all the ships in port, the population of the station is nearly 35,000 active duty military, selected reserve military, and civilian personnel. DOD Contractors perform transportation flights from the air station to NALF San Clemente Island. These DOD Contractors also provide tactical training warfare for the United States Defense Department in joint efforts with the U.S. Navy and U.S. Marine Corps. Most of the traffic enters the base through a single gate. 25,000 vehicles enter and exit that gate.

Figure 3. Energy Generators

This map diagrams the areas which can be power generation areas. These area exerience a high volume of vehicular traffic daily. So where does that energy go? Why aren't we capturing it? If the eMAT were installed on the main arteries then the base could benefit from the energy required to move vehicles from the main gate to their workspaces or sleeping quarters.

So how much energy will the eMAT harvest from the main entrance/exit to the base? In the following calculations, we will use the 3,900 total linear feet of roadway from the main gate entrance to the main gate exit. There are 4 lanes in each direction of travel. Lets consider the known values:

Piezos:

The PZT's density is ~	7.75 g/cm3
weight ~	25 grams.
Compressive strength:	> 600 x 106 N/m2
Tensile strength: ≈	80 x 106 N/m2
# of piezo/m=	10
diameter of ea piezo=	.0635m
height of ea piezo =	.0127m
dist=	1188.72m(approx)
width of 4 lanes=	14.63m
avg width of a tire=	225mm
# of tires on a vehicle=	4
avg dia of a tire=	.702m
# of revolutions/course=	620.46 revolutions

The maximum operating temperature for the piezo for this application is 150°C.

Now, assuming that the average tire width will cover 3 piezos, and 4 tires/vehicle, then we deduce that a single vehicle will deform **7,745.47 piezos in a course.**

Then, we can calculate the amount of energy harvested by each piezo using the following formula. The equation for static voltage output for a piezo disk:

$$\mathbf{V = g33\ F3\ t\ /\ \pi\ r2} \qquad \textbf{(1)}$$

g33 : Longitudinal Voltage Coefficient ~25 x 10-3 Vm/N

F3 : Applied force in Newtons

t: Thickness of disk in meters

r: Radius of disk in meters

So a single vehicle will produce XXXXX voltage/course

25,000vehicles/day will produce XXXXX volts/day

Figure 4. Power Generation Facilities

And once that energy has been captured, then how do we collect, convert, manage, store, and redistribute it? A segment of the pGEN Portfolio addresses that question. By creating “zones” or micro-grids, then each zone can have a dedicated Energy Processing Unit(EPU) that in turn is serviced by a Central Processing Center(CPC). For redundancy, the CPC has an integrated back up system.

What about safety? Is the eMAT safe for motorcycles? What about traction? What about snow plows in the winter? Will they be able to plow the surface in the winter? Will road salt damage the mechanics of the neoprene material or cause rapid corrosion? Can ice build up cause it to stop working or break. All these concerns will need to be researched, even though those issues are being addressed. If this is intended for high traffic high speed lanes, then the eMAT must under any and all conditions. Many have the impression that these inventions are intended for just off ramps. The media glowingly describes similar products as if they were going in to intersections and city streets; the pGen Family of invention goes far beyond that. And even if they were placed before an intersection, they would NOT still steal energy from the vehicles.

The kinetic energy generated here is a vertical kinetic energy caused by the weight of the vehicle. This is used to push the spring downwards. Now to get to the next spring, there is a small diagonal increase with both a vertical and horizontal component. The small horizontal component is probably very small and negligible in terms of total horizontal kinetic energy lost. Especially so if they can develop electric cars. According to the First Law of Thermodynamics, there is still a loss of energy. Of course, assuming two things here: (1) that electric cars will make up a majority of transport in the future, and (2) that, rather than people charging up their own cars, there will be 'charging stations', like modern gas stations. The pGEN Porfolio can be placed in areas where vehicles move slower or even parked. It will not damage the mat's ability of harvest eneergy. And of course this system of inventions CAN be placed in high speed roadways without stealing energy from the electric vehicles.\lAnd what about the benefits for our uniformed services/DOD? Lets take a quick look at the constant ever evolving challenges that our military faces.

The Department of Defense (DOD) is looking to significantly increase the installation of renewable energy projects on US military bases over the next decade. Some of the first military projects out of the gate have been utility-scale solar PV projects in Arizona and Georgia. While utility-scale solar is a necessary and permanent stage of solar development in the electric utility sector, and while these projects appear to show progress toward a smart strategy of a strong, diversified, energy supply for our nation, they in fact face significant problems.

In the interests of full disclosure, my firm is a strong supporter of utility-scale solar and provides services to clients in this sector; however, this particular issue is one that needs to be more fully explored for its policy implications.

One problem centers on the duration of the federal procurement processes. DOD clean energy projects take longer to develop and finance than private sector projects. Growing solar companies in a white hot market find the duration of these negotiations tough to endure in an incredibly competitive sector. Yet, regulated utilities can outwait private competitors by drawing on deep cash reserves, resulting in uncompetitive, expensive power bills for U.S. taxpayers.

A second problem with allowing regulated utilities to build, own and operate federal solar facilities is increased federal dependence on state-run public utilities. If a base commander, for instance, hinted at opening up a facility to cost-saving competition, the incumbent utility could use public and private powers to stifle competition. Utilities have nothing to gain, and much to lose, by the U.S. government's plan to diversify its energy sources and competing power contracts. What's best for the civilian government military and American people might not be viewed as the best option for utility executives and their shareholders.

U.S.-based military facilities that include critical military command centers and other key operational assets require 100% energy reliability as a matter of national security. The best way for our military and the government to ensure reliability, control its assets and achieve some of the well-planned federal renewable energy goals is free market competition. Simply put, we need full allowance of modern, private financing structures for federal solar facilities, including third-party financing of solar on DOD facilities.

Modern third-party contracts, called power purchase agreements (PPAs), are used every day in the private sector to power facilities that range from Wal-Mart stores to General Motors factories to the corner hardware store. PPAs would cut electricity costs to bases and save taxpayer dollars. PPAs also offer the most flexible economic solution to meet military base energy demands and manage and lower energy costs, while increasing base as well as national security. However, in states like Georgia, North Carolina and South Carolina these types of agreements are not allowed, ultimately preventing third party PPAs and unwanted competition from the private sector.

To take advantage of the growing demand of solar, particularly in these states without third party PPA agreements, utilities are using their significant resources to finalize deals to install solar projects on military bases that they would own and operate. While these solar projects would be located on site, the base would not be able to depend on this solar generation for energy reliability as it would likely go into the grid under the discretion of the utility. As a result, these project costs would ultimately fall on local ratepayers and allow utilities unilateral control over the electricity generation as well as too much overall control at U.S. military bases.

Along with allowing 3rd party, private PPAs, there are other ways in which the DOD can put solar to work powering military bases. While some of these actually improve behind the fence energy security and energy reliability, others are just cosmetic.

1. DOD can purchase, own and operate a solar system on site where it uses the electricity. Federal tax rules generally prevent this.

2. DOD can lease and operate a solar system on site where it uses the electricity. Federal tax rules generally prevent this.

3. Using an Enhanced Use Lease (EUL), DOD can lease land/real estate to a private company and the private company can own and operate a solar system on site. This makes rental income for the DOD/U.S. Taxpayer, but does not provide solar electricity directly to the base if the electricity feeds into the utility grid.

4. DOD can lease land/real estate to a private company and the private company can own and operate a solar system on site, with or without an Enhanced Use Lease, and that private company can sell its output only to the utility. Again, this makes rental income for the DOD and deploys solar in America, but no clean electricity would feed DOD and base security would not improve.

5. A private company can install, own, and operate on a DOD site a solar system and sell electricity to a utility that serves the DOD site. The utility can then re-sell that same electricity to the DOD at that site at a cost savings. Utilities propose this as a

way to prevent third party electricity sales. However, it is uncertain if this really enhances behind the fence DOD base security and reliability benefits. Regardless, this puts the utility in the middle of DOD business and financing and generally complicates matters for the private solar owner as well as the DOD.

6. An electric utility can install, own, and operate on site a solar system and sell electricity to a DOD facility at that site. This could provide "behind the fence" security and reliability benefits to the site if the deal is structured right. However, if the system is built by the utility that also owns and operates the system then the cost of that system is actually carried by local ratepayers.

While these options above get solar power projects built on military bases, some are not financially feasible and others give too much control to the utilities which directly impairs base security as well as national security.

7. The best option in terms of cost savings, reliability and security is to allow the DOD to buy electricity from a private company that builds, owns and operates a solar system on site. This is essentially the same as the DOD buying electricity from a utility, but at a cost savings and with increased on site security as the base will be free from the utility grid. However, this option is only possible in those states that allow third party PPAs.

In all of these cases solar is physically located on the base, however not all of these scenarios mean that the base is using its generated solar energy on site. Once the utility gets its own systems on a base, that location is lost to new power development for decades. We need to be sure the military has the best choices for its financial and security needs with the ideal finance structure for its electricity generation. That means free market competition and third party PPAs.

The integration of renewable energy sources with integrated energy storage enables self-sustained micro-grid operation that offers significant energy security and surety benefits for DoD bases. Less dependence on grid-supplied power and reduced on-base fuel consumption decreases vulnerability to the energy market.The micro-grid capability will allow the site to operate independently and efficiently during grid outages due to accident or malicious attack. The hybrid generation system also offers benefits in terms of energy consumption, cost, and greenhouse gas reductions compared with alternative systems that do not include energy storage. The system includes a low-cost, high-efficiency, highly secure means to implement Level 3 EV charging from the DC bus, which reduces roundtrip energy losses and can augment the total available energy storage. The pGEN Family is a concept that contains several technologies addressing the energy demands of a modern world. This family concept of energy producers, collectors, converters, and distributors are all an integral part of a multi-prong approach to energy solutions. With zero emissions, these inventions has commercial, industrial, residential, and even military applications.

Traffic studies show more than 250 million vehicles are registered in America, and an estimated 6 billion miles are driven on our nation’s roads every day. If the kinetic energy generated by moving vehicles was captured at any given moment, it could produce enough electricity to power over a quarter million homes each day. The pGEN Family utilizes technologies which harness excess vehicle energy ('kinetic' or 'rolling' energy) and convert it to sustainable electricity. These roadway-based energy harvesting systems are an alternative energy technology which captures kinetic energy of high speed travel and creatively converts this captured energy to usable electricity.

The pGEN Family is best suited for high traffic locations where vehicles are moving rapidly but can it easily be used on parking lots as well. Example installation sites include busy intersections, highways & freeways, surface roads, and parking lots to name just a few.

The concept of harvesting energy from passing vehicles dates back at least to the Industrial Revolution. All vehicles in motion possess kinetic energy. Kinetic energy refers to the energy of motion, and is best described as the extra energy an object possesses due to its motion, such as the energy observed when a ball is thrown or kicked or when a cyclist no longer needs to pedal a bike in order to continue forward motion.

The pGEN Family of products to effectively harvest a vehicle's kinetic energy, they should be installed at sites where vehicles are traveling at a high rate of speed. Once fully optimized and installed, I anticipate that pGEN Family may be used to supply electricity to a variety of customer applications, including: fixture, building controls, lighting, back-up systems, roadway signage, and other electronics, appliances, and devices used in commercial settings.

CHAPTER 8

RETRO-FITS & UPGRADES

Renewable-based energy micro-grids can produce up to 100% of the total electric energy consumed in Department of Defense (DoD) buildings, depending on the availability of renewable sources. Assuming that the technologies demonstrated will enable the future installation of 500kW of renewable in each of the 5,429 DoD sites, 2.8 billion kWh could be produced annually. This represents 70% of the 3.8 billion kWh per year of electricity consumed by DoD facilities in 2006. Based on the assumptions of 12% average capacity factor, $0.09/kWh electricity price, and 606 kg of carbon dioxide released per every MWh of electricity generated, the project can result in cutting utility bills by $260 million/year and reducing the release of carbon dioxide by 1.7 million metric tons.

But how do we upgrade or retrofit our bases and installations? One of the challenges is improve the bases' capability to generate its own power while being fully functional. This upgrade has to be seemless; no power interuptions. Another primary challenge that many bases face, especially ones located in heavily populated areas, is real estate. Some renewables require large land masses. While others may require large processing plants. The eMAT Portfolio can be easily integrated in to the existing infrastructure without any major down time or disruptions.

1. Net Zero Energy Installation Concept

The US Army has begun working towards a clean energy concept based on a base creating its own energy. Net zero energy is a concept of energy self-sufficiency based on minimized demand and use of local renewable energy resources. While net zero energy status may not be inherently a high priority for DoD installations, it can serve as a design point well suited to a disciplined exploration of how energy is provided and used. First developed in the context of individual houses, where the challenge is to provide all required energy using on-site renewable resources, the concept has been extended in recent years to communities, campuses, and military installations. In principle, a net zero energy installation should reduce its load through conservation (use what is needed) and energy efficiency (typically the most cost-effective measure that will allow the highest returns per dollar spent), then meet the remaining load through on-site renewable energy. *Defining a net zero energy military installation is complicated by the need to consider—in addition to individual buildings, public facilities, and infrastructure—the questions of how to treat energy used for various forms of transportation, and mission-specific energy requirements such as tactical fuel demands.*

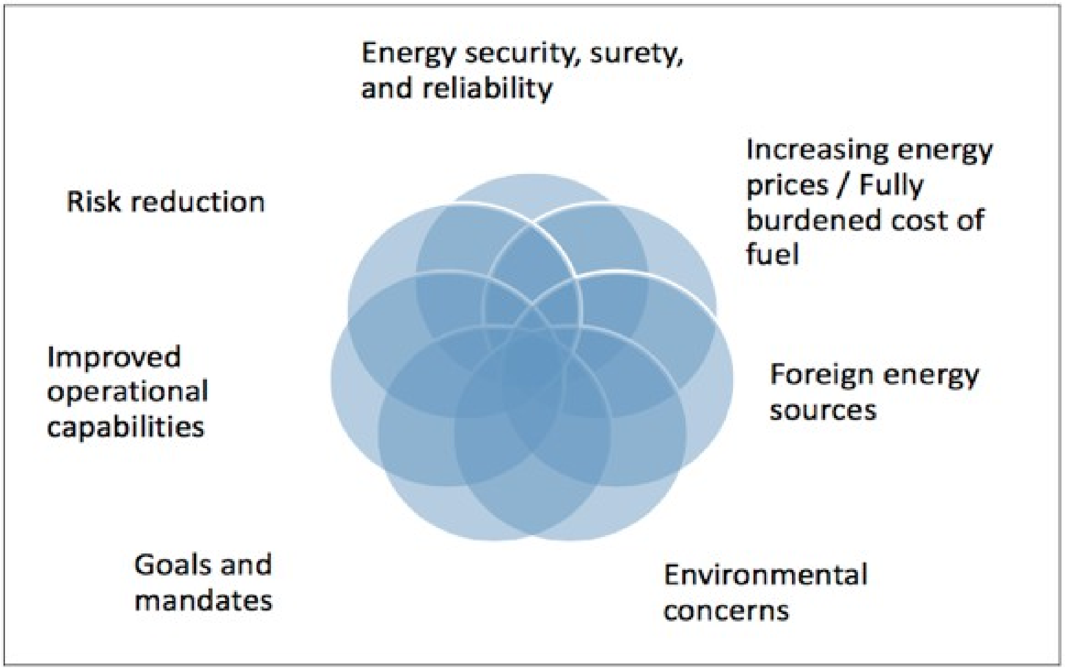


Figure 5. Energy Security, Surety, and Reliability

The original definition of a net zero energy installation adopted by the DoD-DOE task force was, *"An installation that produces as much energy on or near the installation, as it consumes in its buildings and facilities." The definition was elaborated in consultation with the task force and MCAS Miramar to include a focus on renewable energy, on-site generation, and fleet fuel use. The following definition is employed in this guide:*

"A net zero energy military installation produces as much energy on-site from renewable energy generation or through the on-site use of renewable fuels, as it consumes in its buildings, facilities, and fleet vehicles."

A more detailed explanation of this elaboration and the net zero definition is given below:

> *"Net Zero" means that the energy produced on-site over the period of a given year is equal to the installation's energy demand. This implies a connection to a local power grid, which in a sense "banks" the energy. Thus on-site renewable resources, such as solar energy systems, may produce energy greater than that used by the installation during the day, with excess energy fed into the local grid. At night, when the solar system is not producing energy, the installation can pull the previously "banked" energy from the grid to net out the total consumption.*

Energy consumption may be in the form of electricity, steam or hot water, or the direct use of fuel. A military installation may be a contiguous area or may comprise separate areas. When assessing the energy of the installation, all activities within the defined boundaries are included regardless of whether their energy is managed by the base energy manager, or paid for by different agencies.

A facility is any structure on a military installation that is not a building or fleet vehicle. Examples of facilities include swimming pools and area lighting.

Figure 6. Optimal Energy Strategy.

Figure 7. Flight Operations

CHAPTER 9

BASE DESIGNS CONCEPTS OF THE FUTURE

Operational energy is the energy required to train, move and sustain forces, weapons and equipment for military operations. It accounts for approximately 75 percent of all energy used by the Department. It is vitally important for DoD to minimize the risk and maximize the capability that results from changing its use of energy. In 2010, the Department created the Office of the Assistant Secretary of Defense for Operational Energy Plans and Programs (OEPP) to strengthen the energy security of U.S. military operations. The mission of the office is to help the military services and combatant commands improve military capabilities, cut costs and lower operational and strategic risk through better energy accounting, planning, management and innovation. In focusing on energy for the Warfighter, the goal of the “Operational Energy Strategy” is to ensure that the armed forces will have the energy resources they require to meet 21st century challenges. This strategy outlines three principal ways to a stronger force:

1. Reduce the demand for energy in military operations.

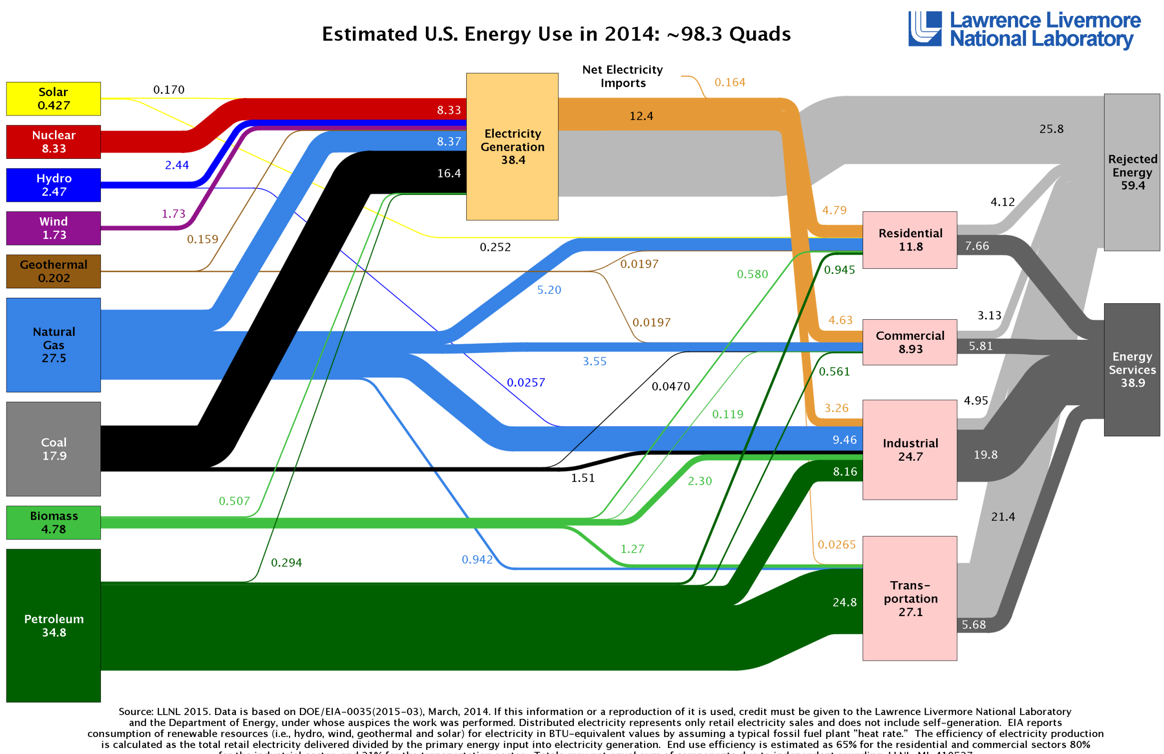
Today’s military missions require large and growing amounts of energy with supply lines that can be costly, vulnerable to disruption, and a burden on Warfighters. The Department needs to: reduce the overall demand for operational energy; improve the efficiency of military energy use in order to enhance combat effectiveness; and reduce military mission risks and costs.

2. Expand and secure the supply of energy to military operations.

Most military operations depend on a single energy source, petroleum, which has economic, strategic, and environmental drawbacks. In addition, the security of the energy supply infrastructure is not always robust. This includes the civilian electrical grid in the United States, which powers some fixed installations that directly support military operations. The Department needs to diversify its energy sources and protect access to energy supplies in order to have a more reliable and assured supply of energy for military missions.

3. Military Facility Energy Use

Twenty- percent of the U.S. military's energy consumption occurs at its installations. DoD pays around $4 billion annually to provide power to its 300,000 plus



facilities in the U.S. and around the world. DoD has made improvements in installation

Figure 8.Sankey Chart 1

energy systems and management a priority, driven by the desire to provide maximum mission support through improved security of supply and reduced costs.

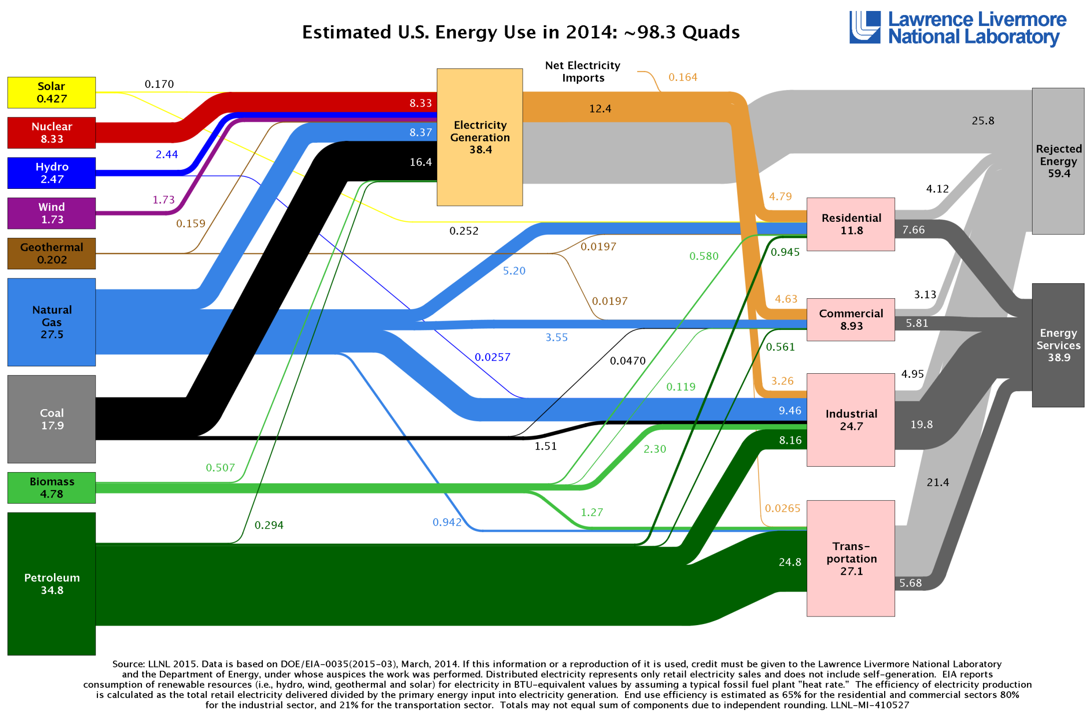


Figure 9. Sankey Chart 2

Addressing cybersecurity is critical to enhancing the security and reliability of the nation's electric grid. Ensuring a resilient electric grid is particularly important since it is arguably the most complex and critical infrastructure that other sectors depend upon to deliver essential services. Over the past two decades, the roles of electricity sector stakeholders have shifted: generation, transmission, and delivery functions have been separated into distinct markets; customers have become generators using distributed generation technologies; and vendors have assumed new responsibilities to provide advanced technologies and improve security. These changes have created new responsibilities for all stakeholders in ensuring the continued security and resilience of the electric power grid.

Here are some ideas on achieving energy security.

1. **Deliver Energy Security.**
2. **Tactical Energy Efficiency In order to move towards the Department of Defense needs**

   Renewable energy could allow the American military in combat zones to go farther, longer, and more quietly. Climate change was not a first or second reason given for the embrace of any of these renewable energy innovations, but they still reduce CO_2 emissions.

   Each military base, as directed by executive orders and Military Leadership security initiatives, seeks to reduce energy demand through implementing renewable energy conservation projects.

3. Produce Renewable Energy.

Provide Environmental Stewardship.

Optimizing waste streams use with the goals of landfill diversion and cost reduction, bases could reduce their impact on the environment.

CHAPTER 10

STRATEGIC ENERGY

Operational Energy (OE) is defined in statute as the "energy required for training, moving, and sustaining military forces and weapons platforms for military operations," and includes energy used by ships, aircraft, combat vehicles, and tactical power generators. Operational energy includes energy used by tactical power systems and generators, as well as by weapons platforms themselves. The Department considers operational energy to be the energy used in military operations, in direct support of military operations, and in training that supports unit readiness for military operations, to include the energy used at non-enduring locations (contingency bases)*.

In Fiscal Year 2014, the Department used over 87 million barrels of fuel, at a cost of nearly $14 billion. Overall, operational energy comprised 70% of the Department energy use by volume.

The ASD(EI&E) is the principal advisor to the Secretary of Defense and the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) on matters relating to energy, installations and environment; and the principal advisor to the Secretary of Defense and the Deputy Secretary of Defense regarding Operational Energy (OE) plans and programs. In September 2015, Ms. Amanda Simpson was sworn in as the Deputy Assistant Secretary of Defense for Operational Energy, DASD(OE).

CHAPTER 11

ENERGY ON THE MOVE (OPERATIONAL ENERGY)

1. Operational Energy in Warfighting

Energy has long been a fundamental enabler of military operations. From hay for Napoleon's horses to coaling stations for the Great White Fleet to fuel for General Patton's breakout from Normandy to the advent of aerial refueling and underway replenishment to supporting distributed contingency bases in Afghanistan, energy – mostly petroleum – is a prerequisite for military power. Today, operational energy enables movement, speed, endurance, time on station, and range by Joint forces in the air, on land, and at sea.

However, the Department's ability to deliver operational energy to where and when it's needed is at increasing risk. For instance, the difficulty of moving energy across the last tactical mile of resupply, in the face of improvised explosive devices, irregular adversaries, and insurgent attacks will remain a part of the operational environment. Likewise, our ability to project and sustain power worldwide will be challenged by anti-access, area-denial (A2/AD) weapons able to target our combat and logistics forces with long-range precision. Together, A2/AD threats, hybrid adversaries, and the tyranny of distance mean a greater risk to assured delivery of operational energy.

2. Mission

The mission of the ODASD(OE) is to assure the delivery of operational energy to military forces training and operating around the globe.

Our strategy includes three objectives:

1. **Increase Future Warfighting Capability.** First and foremost, the Department is focused on increasing long-term warfighting capability. Systems under development need to be evaluated for their effectiveness and supportability in the types of combat scenarios in which they are expected to be used. The Department will improve future combat effectiveness and capability by thoroughly integrating energy supportability into capability development and investing in innovation tailored to an enhanced ability to operate in contested environments.
2. **Identify and Reduce Logistics and Operational Risks.** In partnership with OSD, Joint Staff, Combatant Commands, and the Military Departments, the Department now has a better, yet still incomplete, understanding of the specific risks associated with energy in operation plans and in concepts of operations. In order to capitalize on the advances made in wargames, modeling, simulation, and other analytical tools, the Department will focus on identifying risks and prioritizing resources for their mitigation.
3. **Enhance Mission Effectiveness of the Current Force.** The Department also understands the importance of improving energy use in combat and peacetime missions carried out around the globe every day. The Department will pursue a

range of materiel and non-materiel initiatives that improve energy use in the near-term.

> As appropriate, priority will be given to near-term initiatives that improve the robustness and flexibility of the energy supply chain, enhance the ability to operate in contested environments, and support the rebalance to the Asia-Pacific region.

Clean and efficient energy are essential to enhance troop performance and safety. Military planners have underscored the idea that energy efficiency is a force multiplier. It increases the range and endurance of forces in the field while reducing the number of combat forces diverted to operation and protection of energy supply lines. The Army also has a net-zero energy installation goal to ensure that facilities are able to produce as much energy as they consume. To accomplish this goal, the Army implemented the highest building standard in the federal government. The Army is now piloting bases with "net-zero" energy use across the country.

Again, *the net zero energy installation concept can be seen as a useful entry point into an exploration of demand reduction through human action and energy efficiency technology, and meeting the remaining energy needs with local renewable energy resources. Some installations will be able to exceed net zero status to become net energy producers, while others won't be able to approach it. In fact, a net zero goal too strictly applied can lead to solutions that make poor sense from economic or other perspectives.*

Soldier Power

"Soldier power" refers to the power a dismounted Soldier requires in the field. Hammack said that as the Army loads up Soldiers with new technology, they are also being loaded up with heavy batteries to provide the needed power. In order for the military to achieve its net zero energy goals, every aspect of human and mechanical movement has to be closely assessed to determine if it can be a potential power generator-including the actual service member as well.

Four ways the U.S. military can adopt clean energy for national security

To do this, the Defense Department should:

1. Play a larger role in creating a smarter, more resilient U.S. electricity grid.

The security risks of an aging and inadequate power grid are direct threats to military capabilities.

2. Increase energy efficiency.

According to the Pew Charitable Trust, 20 percent of the Defense Department's energe consumption occurs on domestic bases

3. Develop new partnerships.

Collaboration with government, communities, universities and nonprofit organizations helps maintain readiness standards while enhancing environmental stewardship.

4. Identify new ways to finance energy improvements.

Tighter budgets mean less money to meet multi-level energy mandates.

The DoD’s push for sustainability has a strong national-security component. As the Pentagon sees it, the military’s dependence on foreign oil could cripple it if its supply lines were cut during war or another crisis. According to the DoD’s June 2012 report called Energy Investments for Military Operations, “Improvements in military energy security provide the Department with a unique opportunity to improve efficiency while increasing operational effectiveness.

Among the military branches, the Army is the biggest energy consumer of power, to the tune of $1.3 billion for FY 2013, said Hammack during a briefing to discuss Pew's report. It manages 1 billion square feet of building space.

CHAPTER 12

BASE ENERGY SECURITY STRATEGIES

The DoD has requisitioned the deployment of 3 gigawatts (GW) of renewable energy to power military facilities by 2025. This meets a larger DoD mandate, Title 10 USC § 2911, which directs at least 25 percent of any DoD facility energy consumption come from renewable energy sources. Implementing alternatives has evolved from increasing energy distribution costs, foreign oil dependency, the threat of energy supply disruptions and the need for more secure and clean energy generation and distribution.

1. Army Initiatives

The Army, the most populous branch of the military, consumes less energy than the Navy or Air Force because of the Army's reliance on the Air Force and the Military Sealift Command for transportation. The Army's energy consumption is concentrated in its installations, which consume an average of 21 million barrels of petroleum per year. The DoD's shift toward energy security has encouraged Army energy initiatives, including the Army Energy Security Implementation Strategy, which requires at least five installations meet "net-zero" energy goals by 2020 and deploy 1 GW of renewable energy on their installations by 2025.

Energy initiatives have begun at several bases since the inception of the energy strategy. Fort Stewart, predicted to be one of the largest renewable solar energy producers in the state of Georgia, is constructing a solar farm capable of generating around 30 megawatts (MW) of electricity, which is expected to be the largest project on any DoD installation. Additionally, Fort Hood is implementing a wind and solar project at the installation in Texas that will provide 230 gigawatt hours (GWh) of renewable energy. The Army's implementation of these multiple alternative energy projects will strengthen economic vitality and research in this domain.

2. Navy Initiatives

The Secretary of the Navy objectives include increasing energy security and enhancing warfighter capabilities through the implementation of renewable energy. In FY 2013, relative to its 2003 baseline, the Navy and Marine Corps reduced their combined energy intensity by 19.3 percent. The Navy has a comprehensive goal of producing 1 GW of renewable energy by 2020—five years earlier than the Army. The Navy's energy goals include: energy efficient acquisition, reduction of petroleum use, production of 50 percent clean energy installations on shore, and the sailing of the Great Green Fleet.

The development and deployment of the Great Green Fleet will include more energy efficient ships and aircraft in addition to utilizing alternative energy, predominantly nuclear power. In 2012, the Navy successfully completed one interim goal by demonstrating the capabilities of the Great Green Fleet during the world's largest international maritime exercise, the Rim of the Pacific Exercise.

Prior to 2013, the Navy completed its largest solar project to date, a 14 MW photovoltaic power system at the Naval Air Weapons Station China Lake in California. This installation is expected to save the Navy more than $13 million over the next 20 years and will generate enough clean energy to supply a third of the facility's annual electricity demand.

3. Air Force Initiatives

The Air Force is responsible for utilizing more than 2.4 billion gallons of jet fuel annually, making it the largest DoD energy consumer. Implementation of the Air Force Energy Strategic Plan includes four priorities: improve resiliency, reduce demand, assure supply and foster an energy awareness culture. Like the Army and Navy, the Air Force has a goal of producing 1 GW of renewable energy, but wants this goal to support on-site capacity by 2016. The Air Force is also pushing toward ensuring all new buildings are designed to achieve zero-net-energy by 2030, beginning in 2020.

In FY 2013, the Air Force had approximately 261 renewable energy projects, including solar and waste-to-energy using landfill gas and wind energy. Cape Cod Air Force Station is the first Air Force net-zero installation, using wind power turbines on site. These turbines generate approximately 8,000 MW of electricity, saving Cape Cod an estimated $1 million per year. These projects are a few examples of how the Air Force plans to continue operations by making the shift to alternative energy usage.

The military's shift toward renewable energy is not just a political directive but also an operational imperative. Improvements toward energy alternatives can increase warfighter efficiency, enhance energy security and cut installation and operational energy costs. Between 2010 and 2012, DoD renewable energy projects increased 43 percent and are anticipated to exponentially increase over the next 20 years. DoD's implementation of alternative energy and supporting infrastructure is one area where DoD is utilizing industry to promote research thus fortifying energy security across the nation.

CHAPTER 13

RETURN ON INVESTMENT

Military bases are interested in this model for alternative energy production because it provides the following *Return-On-Investment (ROI).*

DoD has 300,000 buildings and 2.2 billion square feet of space—three times the footprint of Wal-Mart and five times that of the General Services Administration. Again, the Department spends $4 billion a year on the "facility energy" to power these buildings. Thus, the potential savings are enormous. But there are other payoffs from a significant fossil fuel reductions.

1. Reduces costs of vulnerabilities from OPEC shutting the pipeline or other instabilities. In the event of inclement weather or catastrophic circumstances, there is a path to generate electricity and run base operations as a backup support system that does not require outside electricity.
2. Provides Renewable Energy Sources On Base. Funding of alternative energies and energy efficiency is effectively spread between all participating parties, through approved federal funding initiatives now in place.
3. Reduces the Carbon Footprint of the Military. The renewable electricity generated for the base will offset carbon based electricity (typically coal).

Renewable energy is not just a "policy objective" for the armed forces, but also an "operational imperative." The deployable and decentralized energy production possibilities offered by renewable sources, and by enabling technologies like micro-grids, have tremendous implications for the safety, security, and effectiveness of the military. Renewable energy and efficiency improvements can increase warfighter capability, enhance the energy security of its installations, and cut operational and military base energy costs.

Energize: ONR Supports New Energy Partnership

The Office of Naval Research (ONR) remains committed to the development of alternative energy sources for the warfighter and is moving forward with a new research effort that involves partners ranging from naval warfare and engineering centers, to veterans and wounded warrior programs.

As the military continues to move away from dependence on fossil fuels, the Defense Department plans to spend $20 million on a fleet of electric vehicles unique in their ability to export their own power and offset their cost. Camron Gorguinpour, special assistant to the assistant secretary of the Air Force for installations, environment and logistics, said the department expects to lease as many as 500 electric vehicles at six different installations beginning later this year. All will be modified versions of electric vehicles already on the market with costs ranging from $30,000 to $100,000.

The Air Force has the lead on the project, which envisions Los Angeles Air Force Base becoming the first federal facility to replace everything from passenger sedans to shuttle buses with electric versions. “The three main criteria we’re focused on is reducing fleet expense, enhancing mission capabilities and meeting our energy efficiency goals,” Gorguinpour added.

CHAPTER 14

SUMMARY-WHERE DOES THAT LEAVE US?

The ability for a military installation to become a net zero energy installation will depend on many factors, and may not be practically achievable. The overall energy needs of the system are supplied by a smart microgrid that includes battery storage. It is capable of seamlessly integrating energy from a variety of sources including renewables.

1. Reducing Energy Demand by Engaging People

Another intent of this paper is to be a resource for military base designers, and those who provide energy to those bases. Improving the energy efficiency for military installations is not an easy or a quick fix. It will take time in order to reach goals of reduced the military's dependency on fossil fuels and improve our energy security. These suggestions are intended to perhaps challenge the current status quo to push the level of commitment in order to achieve net zero dependency.

The overall goal of a net zero energy assessment is to recommend an optimal energy strategy that will support the installation’s energy goals. In determining this strategy, consideration must be given not only to the net zero energy goal but also to factors including mission compatibility, energy security, project economics, military agency goals, federal mandates, site resources, funding, and staff availability. This last step of project assessment prior to implementation action should address project selection, the implementation approach, and a basic financial analysis at a sufficient level of detail to enable decision makers to proceed with project implementation.

2. Installation Energy Efficiency

Providing secure, stable, and dependable energy for military installations requires taking a drastic measures; starting with drafting congressional laws that promote more energy sustainability and less energy reduction. The Department of Defense in turn, should mandate all military installations to design and layout bases to strict sustainable energy standards and not to energy efficient standards . These standards, by all accounts, has not reduced our dependency on fossil fuels. And although there is probability no one realistic method to attaining net zero energy, there are a few ways in which we can start moving towards that goal. Here are a few of them:

a. Integrated Technologies

Because military installations exists "in every clime and place", we should look to utilize the indigenous energy sources of the area surrounding the bases. Where in some hostile cases that may not be possible, but where it is possible, integrating all low cost, high energy yield technology can drastically reduced our dependency on fossil fuels. This new approach to sustainability should be a formula that takes into consideration all the available energy resources, be it manmade or natural, to provide the necessary power requirements for bases, buildings and structures. This formula should be calculated in the pre-design phase, and not after the fact. For example, in climates with temperatures consistently over 80 degrees for over 8 months of the year, every roof top should be covered with some type of photovoltaic device; not just having a field of solar panels.

And if all the buildings and structures in a desert climate must have solar panels in order to satisfy the energy requirements for the base, then this should be integrated during the pre-design phase. By incorporating sustainability from the onset alone would probably provide at least 50% of the power requirements for US military bases.

Every aspect of a base must be involved. Every single inch of the base must be assessed as a potential energy generator. By looking at everything as a energy generator, we can perhaps, match them with emerging technologies that best fits the area, building, structure, body of water, etc. Most of the large bases have their own gyms, schools, and athletic fields. Perhaps these areas become major sources of energy. Gathering places or frequently utilized places can potentially be the energy harvesters.

b. Build Sustainable Structures

Today we build structures that conserve energy or reduce energy consumption. Going forward, as the need for more energy grows, the need for buildings and structures to not just conserve energy, but to generate energy grows exponentially. Just as we demand our structures to heat, cool, and protect us from the elements, we have to place those very same demands on our structures to generate dependable energy. A truly sustainable building.

To achieve this very aggressive goal, we must change the way we design, build, and power buildings. A building, or any structure, should have the capability to generate its own power. This should be the new standard. Instead of awarding a structure a certification for energy reduction or saving, buildings should be awarded to generate energy.

c. Affordable Sustainability: Supply & Demand

One of the major steps to achieving the net zero goal is driven by economics. The more people involved in the sustainability push, the more affordable energy becomes. More specifically, manufacturers that produce energy products and equipment will drive the cost down of the current technology. As the cost goes down, more and more architects & designers will integrate sustainability in their design process. As more sustainability considerations are integrated in the design process, military bases will have structures that sustains themselves.

d. Personal Responsibility for Personal Power

Military service members use all the smart devices that the civilian population uses. And in some case, even more. After spending 21 years in the Marine Corps, I can tell you for a fact that marines will keep their personal devices charging continuously. Power for military members is free. They can plug their devices in anywhere anytime. What would the impact on the overall power requirements for a building or barracks be if individuals were responsible for generating their own power? This is not a suggestion that service member should pay for the power used, but that they should generate their own energy to power their personal devices.

e. Micro-grids: “In House Power”

With the exception of services that civilians provide, most bases are almost self sufficient. Except when it comes to energy. Just as the civilian community is dependent on power companies to provide power, military bases are no different for the most part. And if that base is located on foreign soil, then providing power really becomes problematic. Small, scalable micro-grids could be one of the possible solution to this problem. By installing these grids with smart technology that power various structures and equipment, any base can gain energy independent. Power generators located throughout the base can supply these grids with “on demand” power. Collecting data on building usage can help clarify how and where we can use energy smarter.

Reports from the U.S. Energy Information Administration show nearly 70% of America’s electricity is generated by natural gas and coal. The environmental impact of greenhouse gas emissions and the rising cost of those non-renewable fuels, along with the potential doubling of global electricity consumption in the coming years, requires the urgent need for creative, sustainable methods of generating electricity. The prospect of sustainably converting vehicle motion and deceleration (vehicle energy) into electricity represents significant positive environmental impact and alternative energy opportunities. I have over 80 patents to be filed, with at least another 70 potential patents in a closely related field. Here are some facts to consider:

The United States has the world‘s largest transportation system. In 2006, Americans traveled 5.2 trillion person-miles in vehicles and moved 4.6 trillion ton-miles of freight. This travel consumed 28.6 quads of energy, all but about 4% in the form of petroleum.

1. Smart Micro-grids and Energy Storage

The current state-of-the-art power grid includes minimal renewable energy, no intelligent distribution, minimal or no energy storage, ad hoc dispatch, uncontrolled load demands, and excessive distribution losses. Micro-grids are envisioned as local power networks that utilize distributed energy resources and manage local energy supply and demand. Micro-grids can improve operating efficiency, enhance the use of renewables, and increase the reliability of electric power delivery systems. Energy technology demonstrations are enabling DoD to better plan, analyze, and evaluate the operational benefits and risks of deploying micro-grids. The introduction of dynamically stable, modular, and cost-effective energy micro-grids that can seamlessly operate in grid-parallel and off-grid modes will reduce DoD energy costs and carbon emissions and make mission-critical loads more resilient and secure.

2. Renewable Energy Generation

To meet its goals on environmental, energy, and economic performance, DoD requires rapid and effective deployment of new clean, secure, low-carbon energy technologies for its installations. Increasing the use of renewable energy sources and achieving efficiency improvements in other non-centralized energy generation alternatives are essential to reduce installations' energy consumption and carbon footprint and improve energy security. Demonstrations are focused on renewable energy sources that are mission compatible and at the appropriate scale for military installations. Cost, performance, and reliability data gathered from operational deployment of innovative renewable energy sources on DoD installations will inform decisions on their widespread applicability across DoD. Demonstrations involve advanced solar, geothermal, and waste-to energy technologies.

3. Advanced Component Technologies to Improve Building Efficiency

Innovative technologies in energy efficient lighting, heating, and air conditioning can reduce energy demand for all types of DoD buildings. Advanced lighting control technologies integrate scheduling, personalized dimming, daylight harvesting, and occupancy sensing to reduce the energy consumed for building lighting needs. Effective use of waste heat and high-performance cooling technology can enhance energy efficiency and comfort while leading to substantial reductions in peak demand on the power grid. Other technology demonstrations focus on advanced controls for increasing boiler efficiency, roof systems, building envelopes, and waste heat recovery.

4. Advanced Building Energy Management and Control Technologies

Building energy systems often consume much more energy than is necessary due to system deviation from the design intent and energy managers' lack of visibility of system performance. Demonstrations of emerging capabilities in building energy management systems, performance monitoring, and diagnostics can enable DoD energy managers to increase building efficiency and reduce utility costs. Retrofitting existing building stocks represents the largest and fastest way to reduce DoD's energy consumption. Existing modeling and simulation tools, however, cannot accurately capture the dynamic coupling among building subsystems. Demonstration projects also focus on developing the methodology and the physics- and dynamics-based analysis tool set necessary to deliver higher energy performance for building retrofits.

5. Tools and Processes for Design Assessment and Decision Making

Building managers, facility managers, regional managers, and DoD portfolio managers require tools and methods to improve their decision making related to energy usage and investments. Demonstration projects are focused on advances both in the design of new buildings and in the identification and design of major retrofits. Energy savings can occur through improved understanding of energy usage, energy needs, and opportunities, but managers often lack adequate information and analytic tools to make optimal decisions. Demonstrations will gather the data needed for DoD to deploy cost-effective, innovative methods to meet energy goals by increasing the performance of decision makers at all levels of the energy usage and management system.

And the deployment of a micro-grid is expected to increase system robustness, resilience and security, deliver higher power security to critical loads, allow renewable integration and enable inclusion of emerging technologies.

REFERENCES

a. Renewable Energy for MilitaryInstallations:2014 Industry Review/February 2014 American Council on Renewable EnergyY (ACORE),www.acore.org

b. Military’s Shift Toward Renewable Energy/Posted on August 12, 2015 by glenn.selby

c. Renewable Energy World.com/Challenges to Financing Renewable Energy Projects on US Military Sites/googleon: all/June 24, 2014 By Lee Peterson

d. Torcellini et al., “Zero Energy Buildings (ZEB): A Critical Look at the Definition,” Golden, Colorado: National Renewable Energy Laboratory, June 2006, http://www.nrel.gov/docs/fy06osti/39833.pdf.

e. Energy. Gov-Office of Energy, Electricity and Reliability http://energy.gov/oe

f. Office of the Assistant Secretary of Defense for Energy, Installations, and Environment/Chris Tindal, Director of Energy Operations/Deputy Assistant Secretary of the Navy for Energy, pulblished November 2012

g. Office of Naval Research website/www.onr.mil

h. Wikipedia, History of Naval Air Station North Island, Coronado, California